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COKE OVEN SMOKELESS PUSHING SYSTEM DESIGN MANUAL

R. O. McClelland

Ford Motor Company

Prepared for:

National Environmental Research Center
Koppers Company, Incorporated

September 1974

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16. ABSTRACT

The report describes the design (by Koppers Co.) and operation of a system to eliminate atmospheric emissions during the pushing of coke from the 45-oven A-battery at Ford Motor Co.'s Rouge Plant in Dearborn, Michigan. The system was placed in operation in June 1972 and, after a 1-month debugging, was accepted as an integral part of the regularly operating battery equipment. The 10-year-old A-battery consists of 45 13-ft high ovens, each producing 12 tons of blast furnace coke at a gross coking time of 18 hours with a "push" scheduled each 15 minutes. The Coke Guide Fume Hood, where the entire coke guide is enclosed with a hood that extends out over the quench car, was used to eliminate the pushing emissions. Prior to the push, the hood is connected to a stationary fume main that is under a partial vacuum; the hot coke emissions generated during the push are conveyed to a high-energy wet-type gas scrubber where the gas stream is cleaned before being emitted to the atmosphere. Clearances between the hood and quench car are held to a minimum to provide sufficient indraft velocities to overcome normal lateral wind effects. These effects have been evident in similar installations in Japan and Germany where wide clearances have been required to permit the quenching car locomotive to pass under the hood. In the A-battery the quench car profile is built up and a 110,000-acfm fan ensures sufficient indraft velocities.

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Coking	Stationary Sources	13H
Iron and Steel Industry	Coke Pushing	
	Coke Guide Fume Hood	11F, 05C
Metallurgical Fuels	Quench Car	21D
Coke		
Gas Scrubbing		07A

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COKE OVEN SMOKELESS PUSHING SYSTEM DESIGN MANUAL

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EPA Project Officer: D. A. Kemnitz

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Prepared for

OFFICE OF RESEARCH AND DEVELOPMENT
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WASHINGTON, D.C. 20460

September 1974

iv

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

In 1970 the Ford Motor Company contracted with Koppers Company to design and construct a system to eliminate the emissions to the atmosphere during the pushing of coke from the 45-oven "A" battery located at the Rouge Plant in Wayne County, Dearborn, Michigan. In June, 1972 the system was placed in operation and after a one month de-bugging period was accepted by Ford as an integral part of the regularly operating battery equipment.

The ten year old "A" battery at Ford consists of 45 - 13 ft.* high ovens that each produce 12 tons of blast furnace coke at a gross coking time of 18 hours with a "push" scheduled every 15 minutes.

The method selected to eliminate the pushing emissions was the "Coke Guide Fume Hood" where the entire coke guide is enclosed with a hood that extends out over the quench car. Prior to the push the hood is connected to a stationary fume main that is under suction and the hot coke emissions that are generated during the push are conveyed to a high energy wet-type gas scrubber where the gas stream is cleaned before being emitted to the atmosphere.

*A list of factors for converting from non-metric to metric units is provided in Section IX.

Clearances between the hood and quench car are held to a minimum to provide sufficient indraft velocities to overcome normal lateral wind effects. These effects have been evident in similar installations in Japan and Germany where wide clearances have been required to permit the quenching car locomotive to pass under the hood. In the Koppers' concept at Ford, the profile of the existing quench car has been built-up to that of the locomotive to enable the reduction of clearances with the coke guide hood. Also the utilization of a fan with a capacity of over 110,000 acfm ensures that the indraft velocities will be maintained at a high level.

This report is submitted in partial fulfillment of Contract No. 68-02-0630 by Koppers Company, Inc. for Ford Motor Company under the sponsorship of the Environmental Protection Agency and will describe in detail the design and operation of the "Coke Oven Smokeless Pushing System" at Ford Motor Company.

CONTENTS

		PAGE NO.
List of Figures		vi
List of Tables		vii
Acknowledgments		viii
Sections		
I	Conclusions	1
II	Introduction	3
III	Process Description	11
IV	Process Design	21
V	Environmental Posture	45
VI	Capital Cost Estimates	49
VII	Operating Costs, Utility Requirements, and Maintenance	53
VIII	Post Start-Up Modifications	59
IX	Units of Measure - Conversions	63

FIGURES

FIG. NO.	DESCRIPTION	PAGE NO.
1	SYSTEM GENERAL ARRANGEMENT	7
2	SYSTEM GENERAL ARRANGEMENT WITH LEGEND	9
3	SYSTEM FLOW DIAGRAM	13
4	WATER FLOW DIAGRAM	15
5	INSTRUMENT FLOW DIAGRAM	17
6	COKE GUIDE HOOD GENERAL ARRANGEMENT	19
7	COKE GUIDE HOOD PLAN	23
8	QUENCH CAR AND LOCOMOTIVE ALTERATIONS	27
9	QUENCH CAR TO PUSHER RAM SYNCHRONIZATION	29
10	FUME COLLECTING MAIN GENERAL ARRANGEMENT AND SECTION	33
11	SEQUENTIAL OPERATION OF FAN LOUVERS AND BUTTERFLY VALVE	35
12	GAS SCRUBBER SYSTEM GENERAL ARRANGEMENT	37
13	GAS SCRUBBER SYSTEM ELEVATION	39

TABLES

TABLE NO.	DESCRIPTION	PAGE NO.
I	UTILITY REQUIREMENTS	55
II	REQUIRED MAINTENANCE	57

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Mr. R. O. McClelland	- Project Director Koppers Company
Mr. D. A. Kemnitz	- Project Officer Control Systems Laboratory Environmental Protection Agency

SECTION I

CONCLUSIONS

The overall goal in preparation of this report is to demonstrate a system designed for coke oven pushing emission control capability, operability, reliability, and maintainability.

Although the system can be used on new installations, it was designed primarily to serve existing coke plants and, at this writing, has been in operation for two years with minimal downtime.

Tests conducted by Koppers Company during October and November of 1972 indicate a scrubber efficiency of 99% and an outlet stack loading of 0.02 grains/scf (dry).

These results, coupled with reliability and automatic operation, make the "Coke Guide Fume Hood" an effective answer to pushing emission control.

Ford Motor Company's satisfaction with the system is indicated by the fact that in early 1974 Koppers was awarded the contract to extend the fume main to serve Battery "AX" and engineering is complete for installation on the remaining batteries, "B", "C", and "DX", in the Rouge coke plant.

SECTION II

INTRODUCTION

The "A" battery in the Rouge coke plant is located at the south end of the six battery (205 operating ovens) complex that includes "A", "AX", "B", "C", "D", and "DX." Battery "D" is out of service, and "AX" and "DX" are comprised of 13 and 25 ovens, respectively.

Ford Engineering requested that the gas cleaning system be sized to allow extending the fume main to include Batteries "AX" and "B" in the future.

In designing the system for an existing battery, consideration had to be given to construction downtime and interference with the constant day to day operation of the coke plant. As a result of these considerations the system becomes an "add-on" device whereby no major alterations to the battery or present method of quenching are required. Also being a fully automatic installation, no additional personnel are required for its operation.

The system is designed for capturing only the emissions generated during the pushing of coke into a standard open-type quench car. These emissions vary with every push; ovens having "green" ends due to insufficient carboni-

zation time or condition of the oven doors generate the most particulate matter, and properly coked-out ovens create relatively little emissions.

During a moderately "green" push there is an acceleration of fume combustion under the hood which tends to clean-up the coke by the time the quench car leaves the hood.

During an emergency situation when the gas scrubber is not functioning due to maintenance on the fan or motor, the door machine operator need only to place the selector switch on "manual", then rack the coke guide in as done normally and no other emission control system functions will occur. The telescoping section of the hood that connects to the fume main will not extend, and when the push is made in the conventional manner, the hot coke emissions will go out the top of the hood to the atmosphere resulting in no downtime of the door machine or coke guide.

Operators of existing coke plants who may be contemplating the installation of this system in their plants might consider the following items that were considered in designing the installation at Ford:

1) Sufficient real estate near the battery on which to place the gas scrubber components.

2) Sufficient clearance on the coke side of the battery to run the fume main and locate the towers that support the fume main truss. Some of the common obstructions in this area are material handling equip-

ment, conveyors, screening stations, coke wharfs, stacks, cross-over mains, and piping.

3) Sufficient bench length to park out the door machine and coke guide due to the additional length of the fume hood seal plates.

In addition to the above items, it is also noted that the wheel loads of the coke guide hood do not exceed those of the door machine, thus eliminating the need to strengthen the bench supports.

With respect to the efficiency of the gas cleaning system, an analysis of the gas stream before scrubbing indicates that it contains 1.76 lbs. of particulate matter per ton of coke, which means that over 21 lbs. of particulate matter are generated during each push. The Wayne County, Michigan, air emission code states that emissions of Ringelmann #2 or greater are to exist for not more than 4 minutes out of any 30-minute period, and the outlet particulate loading is to be less than 0.05 grains per standard cubic foot. These requirements were designed for and met with ease.

Figure 1 - System General Arrangement (Dwg. 319-A626) -- illustrates the various components incorporated into this new system, their interaction with each other, and with the coke oven battery proper. (The components are identified in Figure 2.)

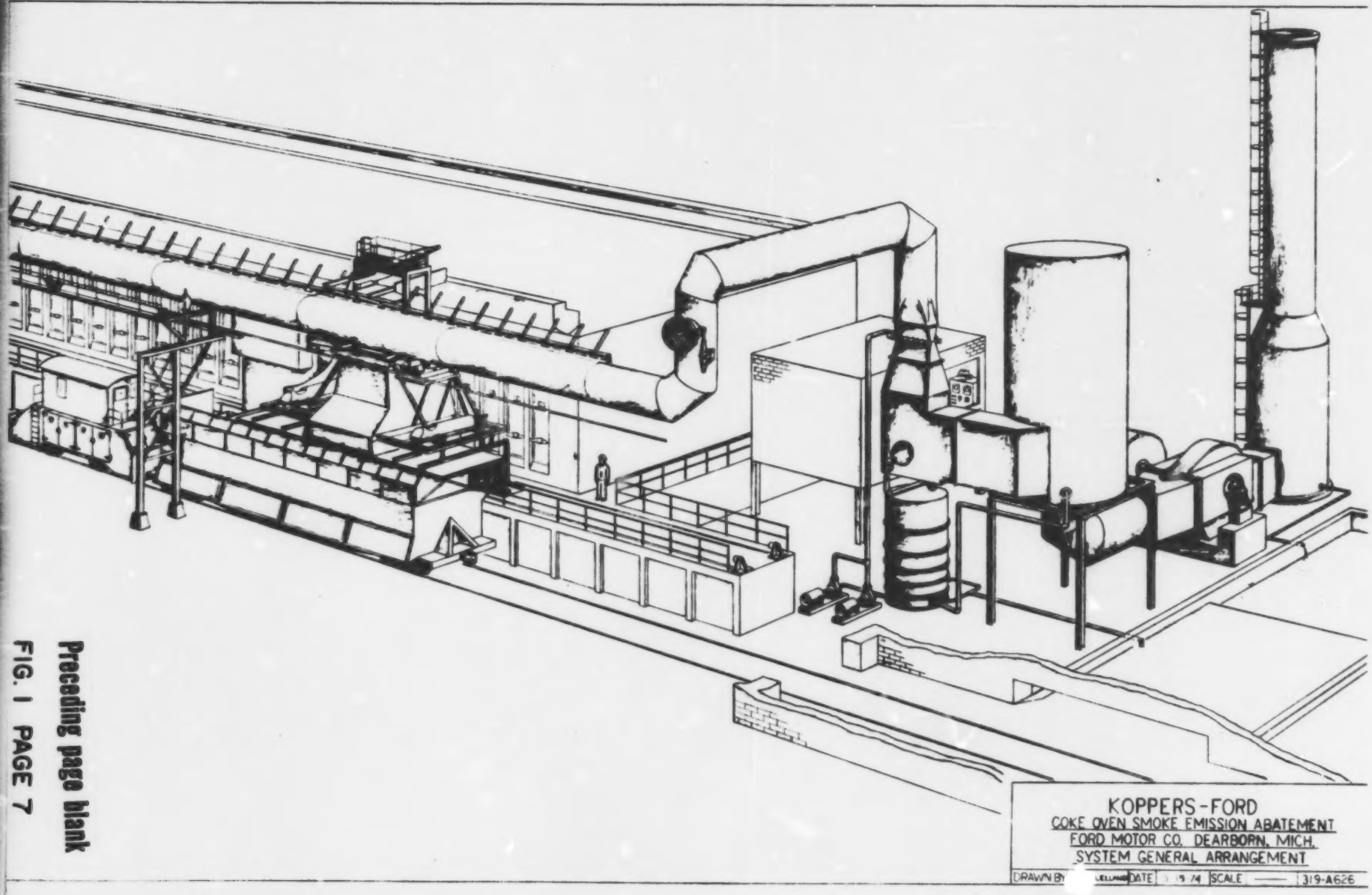

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FIG. 1 PAGE 7

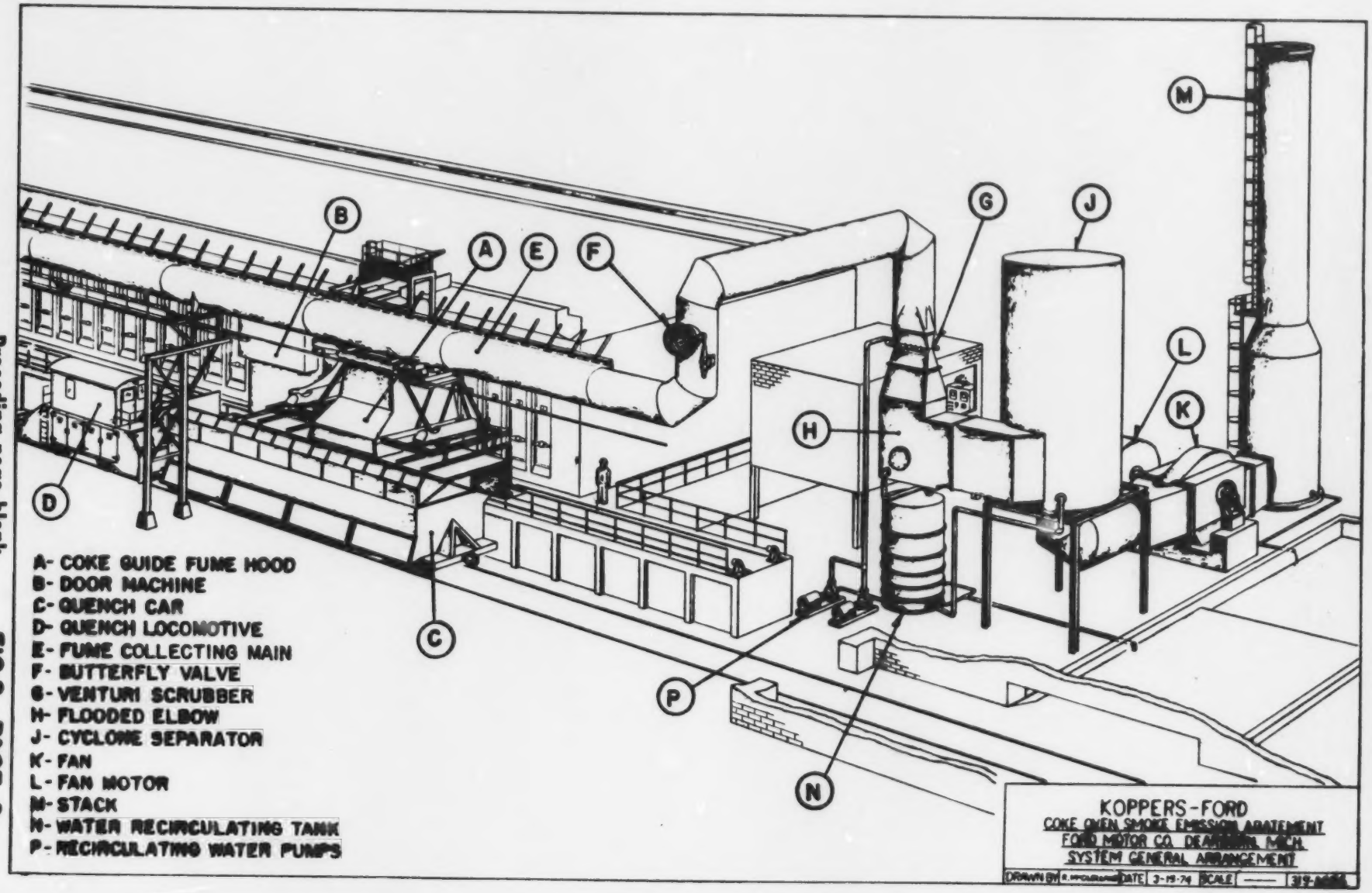

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FIG 2 PAGE 9

SECTION III

PROCESS DESCRIPTION

Figures 3,4, and 5 (Drawings 319-A627, 319-A628, and 319-A629) describe the conditions of the fume hood, fume main and gas scrubber during the coke "push."

Figure 3 (Drawing 319-A627) is a system flow diagram showing the various components and their relative function in making up the complete system.

Figure 4 (Drawing 319-A628) indicates the general application and use of water in the gas scrubber system. Mill cooling water is the source of make-up to the recirculating water system to replace the 50 gpm of dirty water that is drained off to the quenching sump. City water is used at the fan for the cooling of bearings and cleaning of fan blades with the drains from each subsequently going to the quenching sump.

Figure 5 (Drawing 319-A629) is an instrument flow diagram with complete information on the monitoring and control of the process as conceived for this design. The gas flow definition as presented in Figure 3 represents the fume flow quantities at the maximum levels. The fume system discharge indicated on Figure 3 represents the Wayne County, Michigan, requirements, with the actual discharge as measured by Koppers Company being considerably less.

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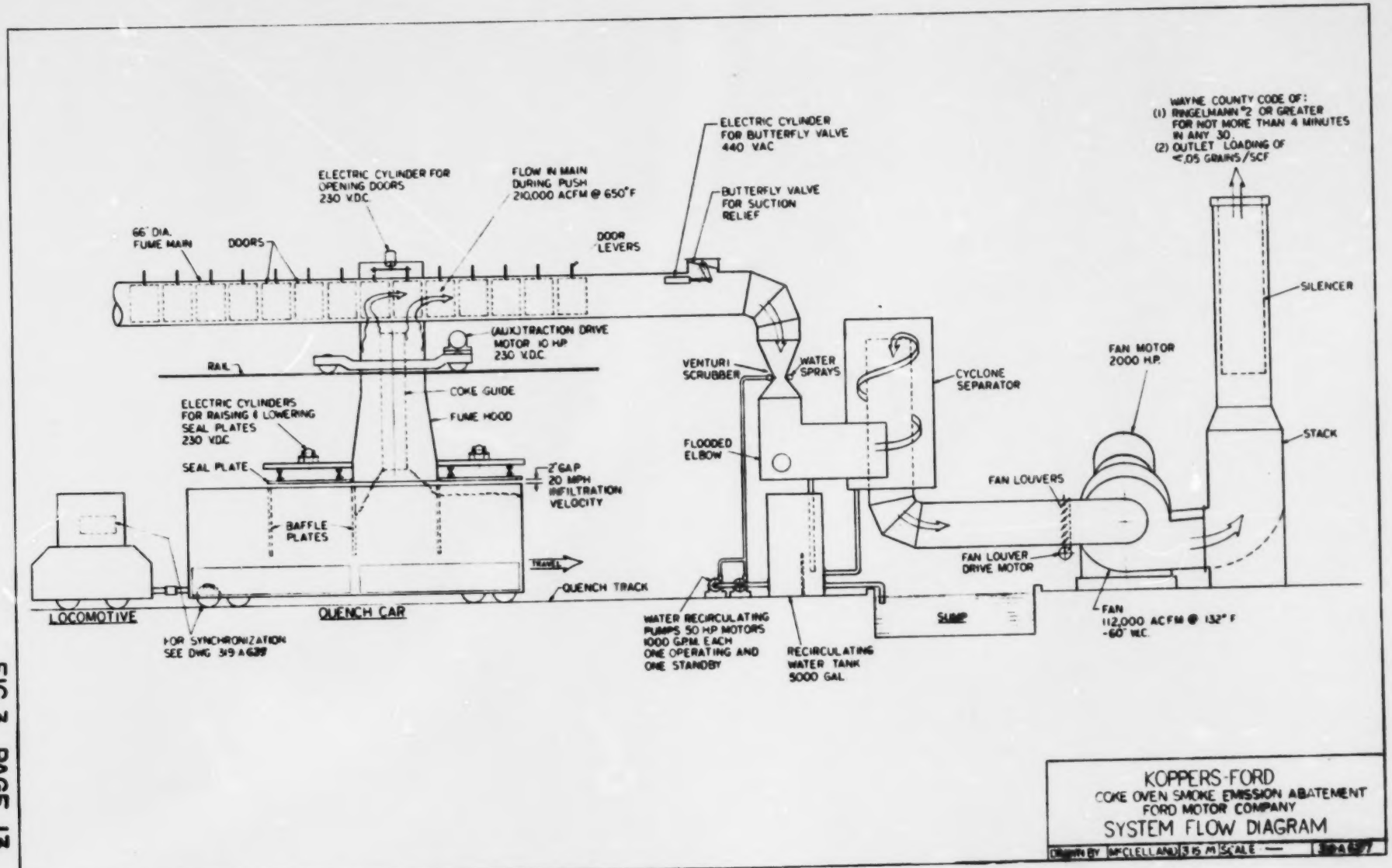
66" DIA. FUME MAIN
DOORS
ELECTRIC CYLINDER FOR OPENING DOORS 230 V.D.C.
FLOW IN MAIN DURING PUSH 210,000 ACFM @ 650°F
ELECTRIC CYLINDER FOR BUTTERFLY VALVE 440 VAC
BUTTERFLY VALVE FOR SUCTION RELIEF
DOOR LEVERS
WAYNE COUNTY CODE OF:
(1) RINGELMANN #2 OR GREATER FOR NOT MORE THAN 4 MINUTES IN ANY 30.
(2) OUTLET LOADING OF <.05 GRAINS/SCF
SILENCER
(AUX.) TRACTION DRIVE MOTOR 10 HP 230 V.D.C.
RAIL
VENTURI SCRUBBER
WATER SPRAYS
CYCLONE SEPARATOR
FAN MOTOR 2000 H.P.
COKE GUIDE
FUME HOOD
ELECTRIC CYLINDERS FOR RAISING & LOWERING SEAL PLATES 230 V.D.C.
FLOODED ELBOW
STACK
SEAL PLATE
2" GAP 20 MPH INFILTRATION VELOCITY
FAN LOUVERS
BAFFLE PLATES
TRAVEL
FAN LOUVER DRIVE MOTOR
QUENCH TRACK
LOCOMOTIVE
QUENCH CAR
SUMP
FOR SYNCHRONIZATION SEE DWG 39A6399
WATER RECIRCULATING PUMPS 50 HP MOTORS 1000 G.P.M. EACH ONE OPERATING AND ONE STANDBY
RECIRCULATING WATER TANK 5000 GAL
FAN 112,000 ACFM @ 132° F -60" W.C.
KOPPERS-FORD
COKE OVEN SMOKE EMISSION ABATEMENT
FORD MOTOR COMPANY
SYSTEM FLOW DIAGRAM
Drawn BY McCLELLAND 3-15-71 SCALE —

FIG. 3 PAGE 13

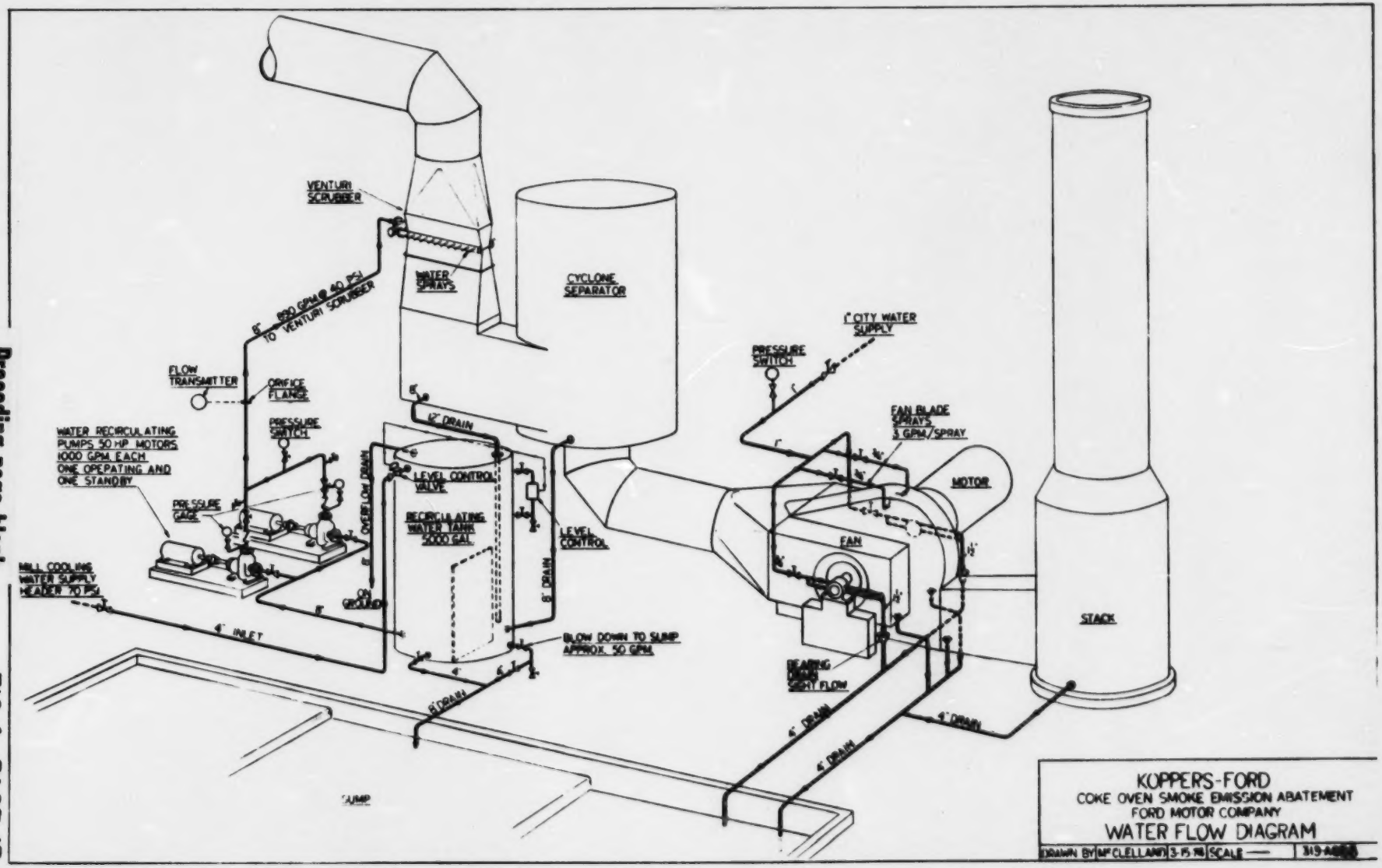

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FIG. 4 PAGE 15

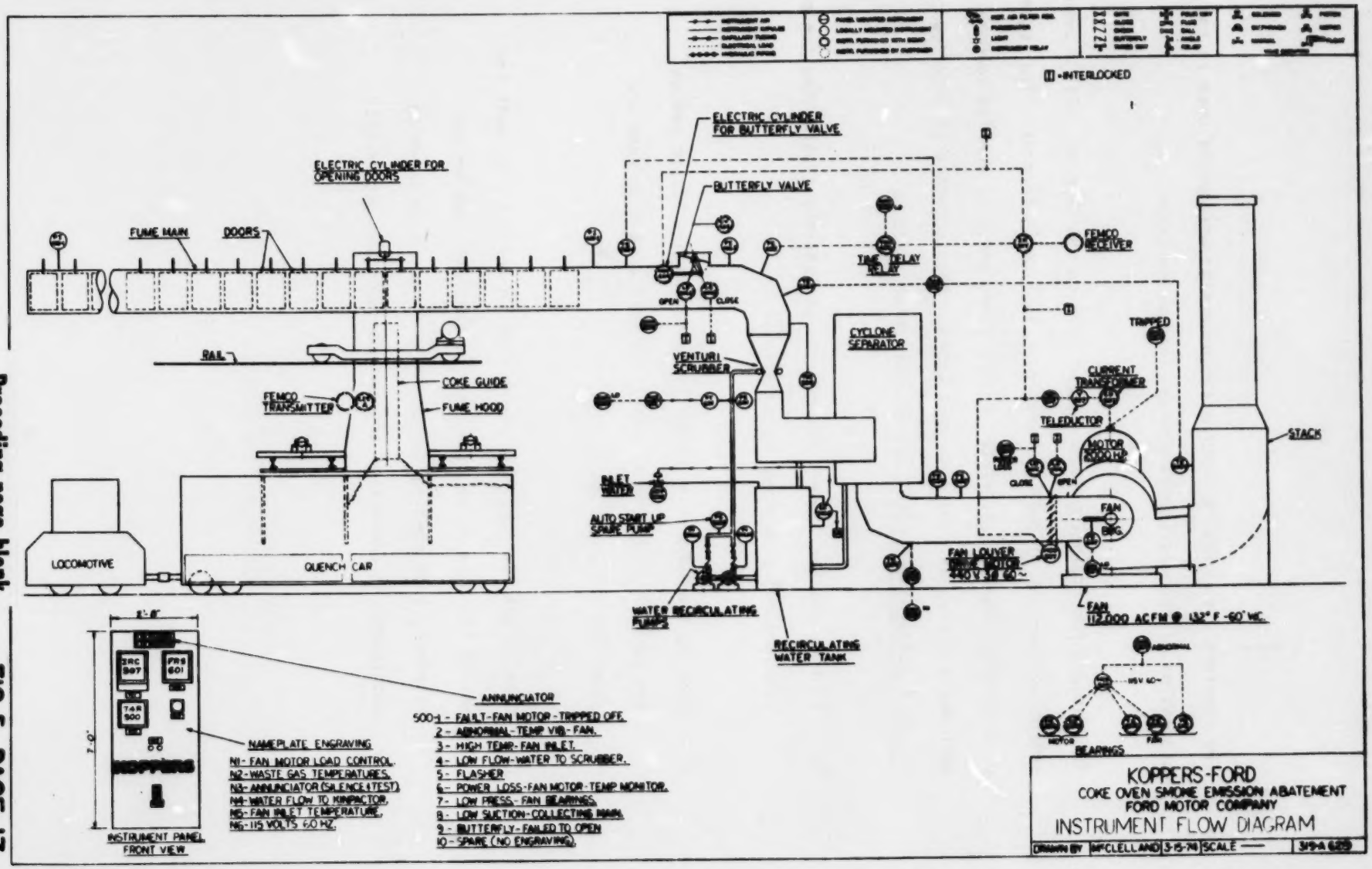

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FIG. 5 PAGE 17

The diagrams also provide information on design parameters used in the processing of the gas stream through the gas scrubber.

The fan and recirculating water system operate continuously with a push scheduled every 15 minutes and each push lasting 40 seconds. The sequence of conditions that exist between pushes comes about by the fan louvers, fume main butterfly valve, and fume main doors. This sequence is described on Figure 6 (Drawing 319-A630) and in essence consists of:

1) Closing the fan louvers between pushes, thereby placing the fan on idle and reducing power consumption.

2) Opening the fume main butterfly valve temporarily to reduce the suction in the main, requiring less effort to open and close the fume main doors.

3) Closing the two fume main doors used in the previous push and moving the coke guide fume hood to the next oven on the schedule, then opening the corresponding two doors which completes the connection between the hood and gas scrubber.

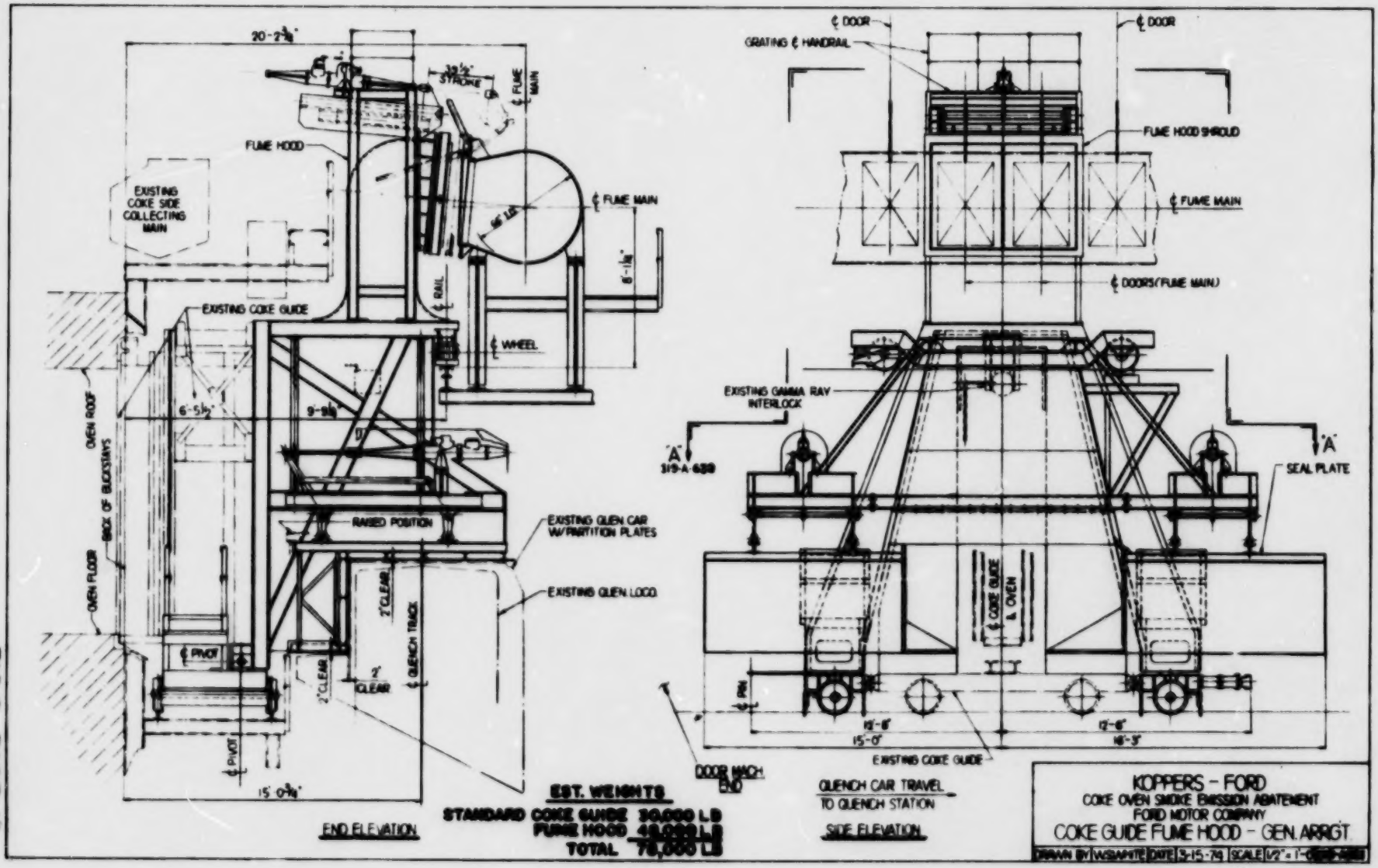
20'-2¾"
33½" STROKE
℄ FUME MAIN
FUME HOOD
EXISTING COKE SIDE COLLECTING MAIN
℄ FUME MAIN
6'-1½"
EXISTING COKE GUIDE
℄ RAIL
℄ WHEEL
6'-5½"
9'-9½"
OVEN ROOF
BACK OF BUCKSTAYS
OVEN FLOOR
RAISED POSITION
EXISTING QUEN CAR W/PARTITION PLATES
EXISTING QUEN LOCO
2' CLEAR
℄ QUENCH TRACK
℄ PIVOT
2' CLEAR
2' CLEAR
℄ PIVOT
15'-0¾"
END ELEVATION
EST. WEIGHTS
STANDARD COKE GUIDE 30,000 LB
FUME HOOD 48,000 LB
TOTAL 78,000 LB
℄ DOOR
GRATING ℄ HANDRAIL
℄ DOOR
FUME HOOD SHROUD
℄ FUME MAIN
℄ DOORS (FUME MAIN)
EXISTING GAMMA RAY INTERLOCK
'A'
319-A-629
'A'
SEAL PLATE
℄ COKE GUIDE
℄ OVEN
PIN
12'-8"
15'-0"
12'-6"
16'-5"
EXISTING COKE GUIDE
DOOR MACH. END
QUENCH CAR TRAVEL TO QUENCH STATION
SIDE ELEVATION
KOPPERS - FORD
COKE OVEN SMOKE EMISSION ABATEMENT
FORD MOTOR COMPANY
COKE GUIDE FUME HOOD - GEN. ARRGT.
DRAWN BY W.SCHMITT DATE 3-15-74 SCALE ½" = 1'-0"

FIG. 6 PAGE 19

SECTION IV

PROCESS DESIGN

This section provides definition of the various major components that are new or have been altered to make up the "Coke Oven Smokeless Pushing System" as defined in Figure 2 (Drawing 319-A626).

A. Coke Guide Fume Hood (Figures 6 and 7 - Drawings 319-A631-632)

The coke guide fume hood captures the pushing emissions normally generated while the coke is in the guide and while the coke is falling into the quench car. This has been accomplished by taking the existing coke guide and enclosing it with steel plate. A spring loaded angle frame was added that forms a vertical seal against the buckstays when the coke guide is racked in. The top section was sealed by welding a canopy plate between the buckstays at each oven.

Over the entire coke guide and extending out over the quench car is the fume hood. The hood is supported by a set of wheels that have been added on the outboard sides of the existing coke guide. These wheels ride on the bench rails and each supports a pivot bearing onto which the oven side of the fume hood rests; the remainder of the hood extends out over the quench track and is supported by means of an elevated third rail that runs the full length of the battery.

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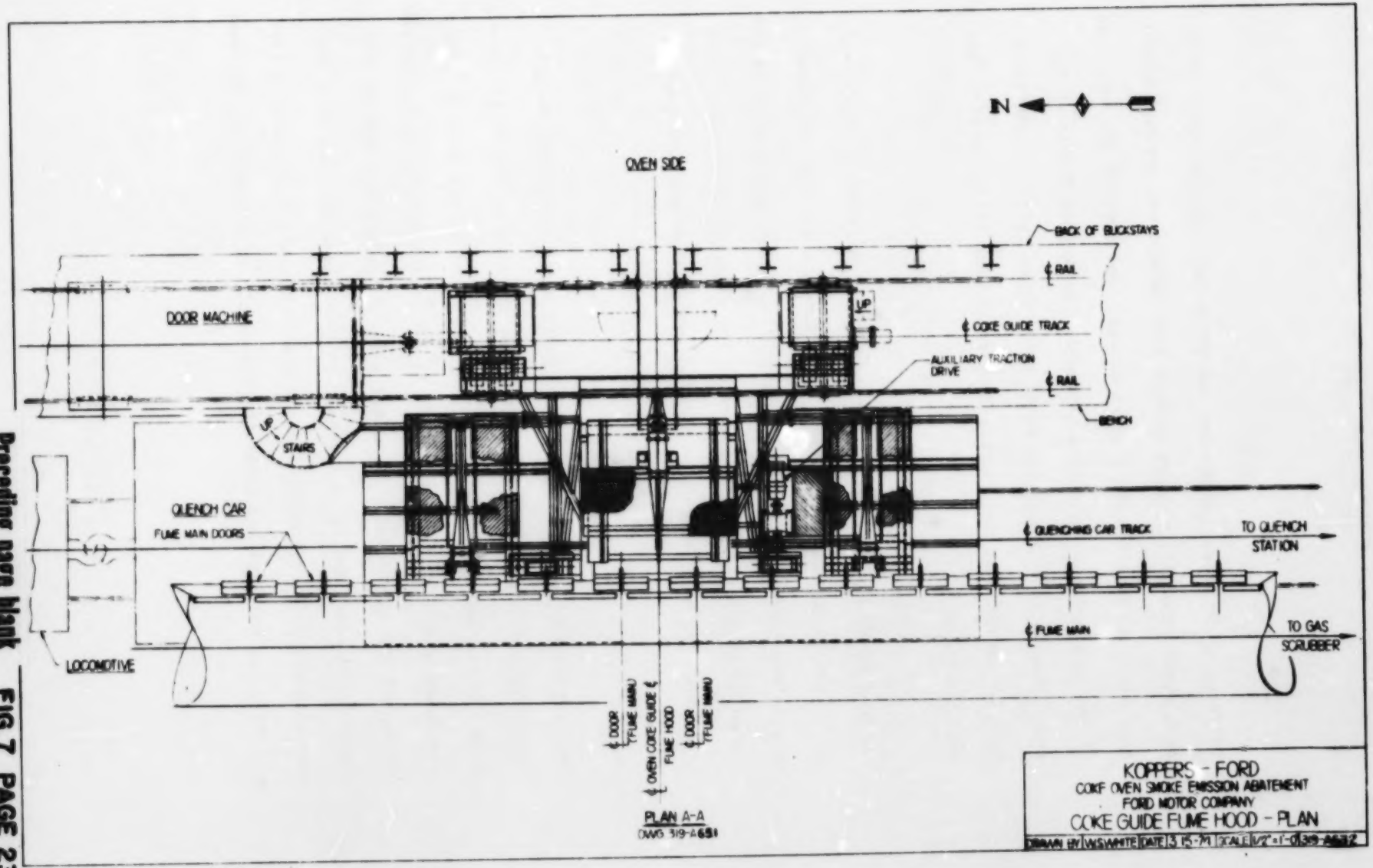

Preceding page blank FIG. 7 PAGE 23

Differences in elevation between the third rail and the bench rails that come about naturally through construction tolerances, thermal growth, age, etc., account for the pivot bearings, that support the oven side of the fume hood, allowing the outboard side to move freely up and down. Any lateral variations between the bench rails and the third rail are compensated for by utilizing extra wide flanged wheels that ride the third rail.

The coke guide is coupled to the door machine which has a traction drive sufficient to move both machines. To compensate for the additional weight of the fume hood and to avoid skewing, an auxiliary traction drive was placed on the fume hood and located on the elevated third rail. This drive has a 10 h.p. motor that is synchronized with the door machine drive.

The fume hood is constructed of steel plate and lined with Cera-felt insulation and stainless steel plates that are loosely bolted in place to allow for thermal cycling caused by each push. The fume hood is fitted with movable seal plates that are 10 ft. in length and fit down over the contour of the quench car. Each seal plate is raised and lowered with an electric cylinder, and it is normally in the raised position to allow approximately 7 in. clearance for the quench car and locomotive to pass by. Prior to the push and after the quench car is in position, the seal

plates are lowered to within approximately 2 in. of the quench car thus cutting down on the infiltrated air and increasing the indraft velocity during the push.

The main body of the hood is approximately 10 ft. long and, with a 10 ft. seal plate on each side, the hood covers 30 ft. of the 40 ft. quench car. Air infiltration through the quench car is kept to a minimum by adding baffles in the car. This will be described later under "Quench Car and Locomotive Alterations".

The captured emissions are directed upward toward the fume collecting main through a snorkle shaped section in the hood. The snorkle section is coupled to the fume collecting main prior to a push by means of an electric cylinder that extends and moves a telescoping section of the snorkle against a flat surface of the main. The fume main is equipped with a series of doors having levers that protrude upward. As the cylinder moves the telescoping section against the main, a bar attached to the cylinder engages the levers and opens two doors that swing into the snorkle section of the fume hood. This completes the coupling of the hood to the fume main. When the push is complete, the cylinder retracts and the doors close under their own weight.

B. Door Machine Alterations

Alterations to the existing door machine included the addition of an electric relay cabinet and an operator's control panel.

C. Quench Car and Locomotive Alterations (Figure 8 - Drawing 319-A636)

The fume hood can only extend downward to a distance sufficient to allow the quench car and quench locomotive to pass beneath. The quench locomotive is approximately 4 ft. higher than the quench car. This necessitated building the sides of the quench car up to equal the height of the quench locomotive. This was done with steel plate as shown on Figure 8 (Drawing 319-A636).

The quench car moves approximately 30 ft. during the push and would require a hood length of approximately 70 ft. if the ends of the quench car were to act as seals during the entire push. By adding three partition baffles in the car as shown on Figure 8 (Drawing 319-A636) a hood length of 30 feet was used with the partition plates sealing the ends during the entire push.

Due to building up the sides of the quench car and covering the coke guide with a fume hood, the quench locomotive operator can no longer see the push and move his car slowly to distribute the coke evenly over the entire length of the quench car. For this reason the "Pusher Ram to Quench Car Synchronization" system, Figure 9 (Drawing 319-A637), was required.

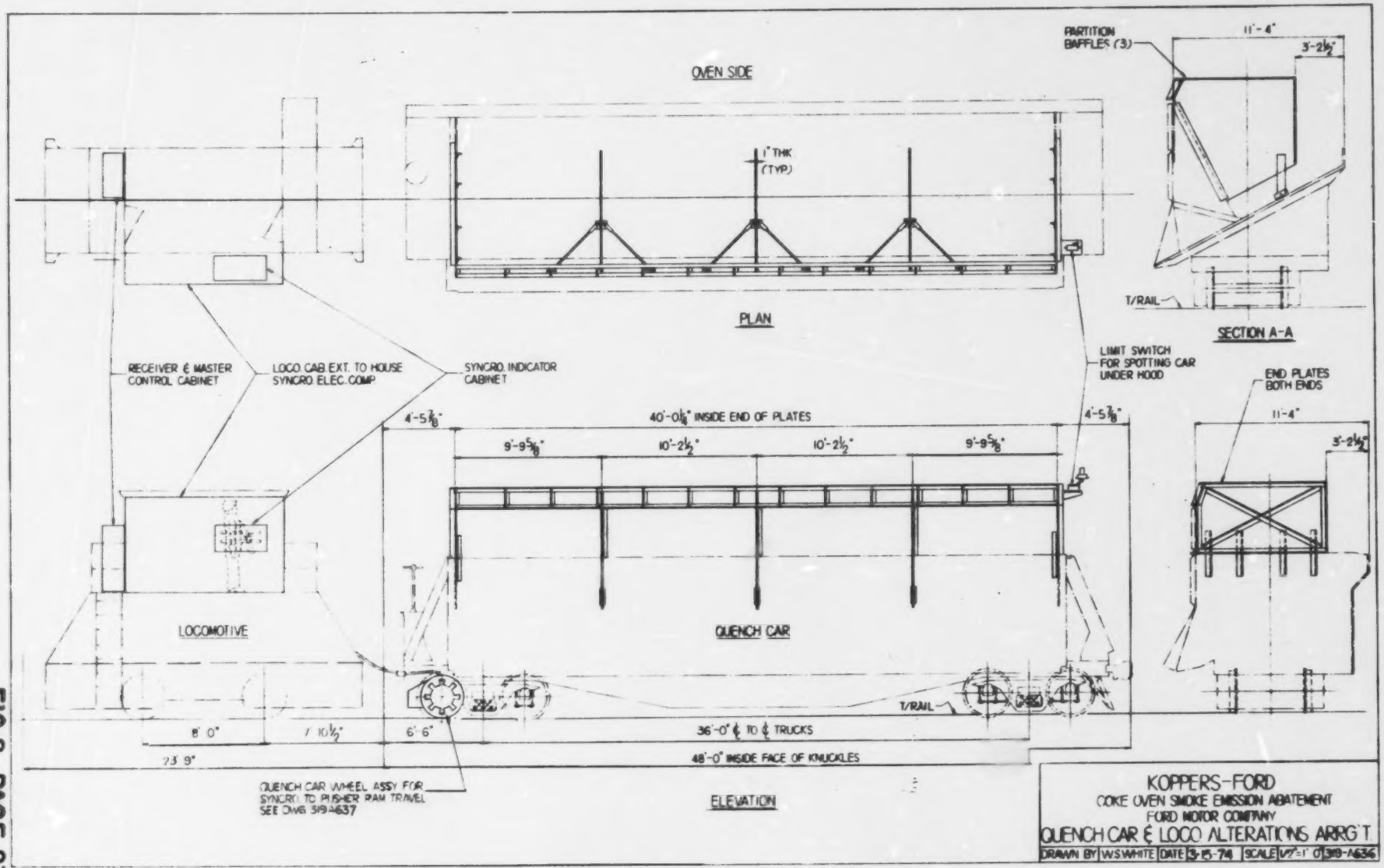
OVEN SIDE
1" THK (TYP)
PLAN
PARTITION BAFFLES (3)
11'-4"
3'-2½"
T/RAIL
SECTION A-A
RECEIVER & MASTER CONTROL CABINET
LOCO. CAB EXT. TO HOUSE SYNCRO ELEC. COMP
SYNCRO. INDICATOR CABINET
LIMIT SWITCH FOR SPOTTING CAR UNDER HOOD
END PLATES BOTH ENDS
4'-5⅞"
40'-0¼" INSIDE END OF PLATES
9'-9⅝"
10'-2½"
10'-2½"
9'-9⅝"
4'-5⅞"
LOCOMOTIVE
QUENCH CAR
T/RAIL
8' 0"
7' 10½"
6' 6"
36'-0" ℄ TO ℄ TRUCKS
23' 9"
48'-0" INSIDE FACE OF KNUCKLES
QUENCH CAR WHEEL ASSY FOR SYNCRO TO PUSHER RAM TRAVEL SEE DWG 319-A637
ELEVATION
KOPPERS-FORD
COKE OVEN SMOKE EMISSION ABATEMENT
FORD MOTOR COMPANY
QUENCH CAR & LOCO ALTERATIONS ARRG'T
DRAWN BY W.S.WHITE DATE 3-15-74 SCALE 1/2"=1' 0" 319-A636

FIG. 8 PAGE 27

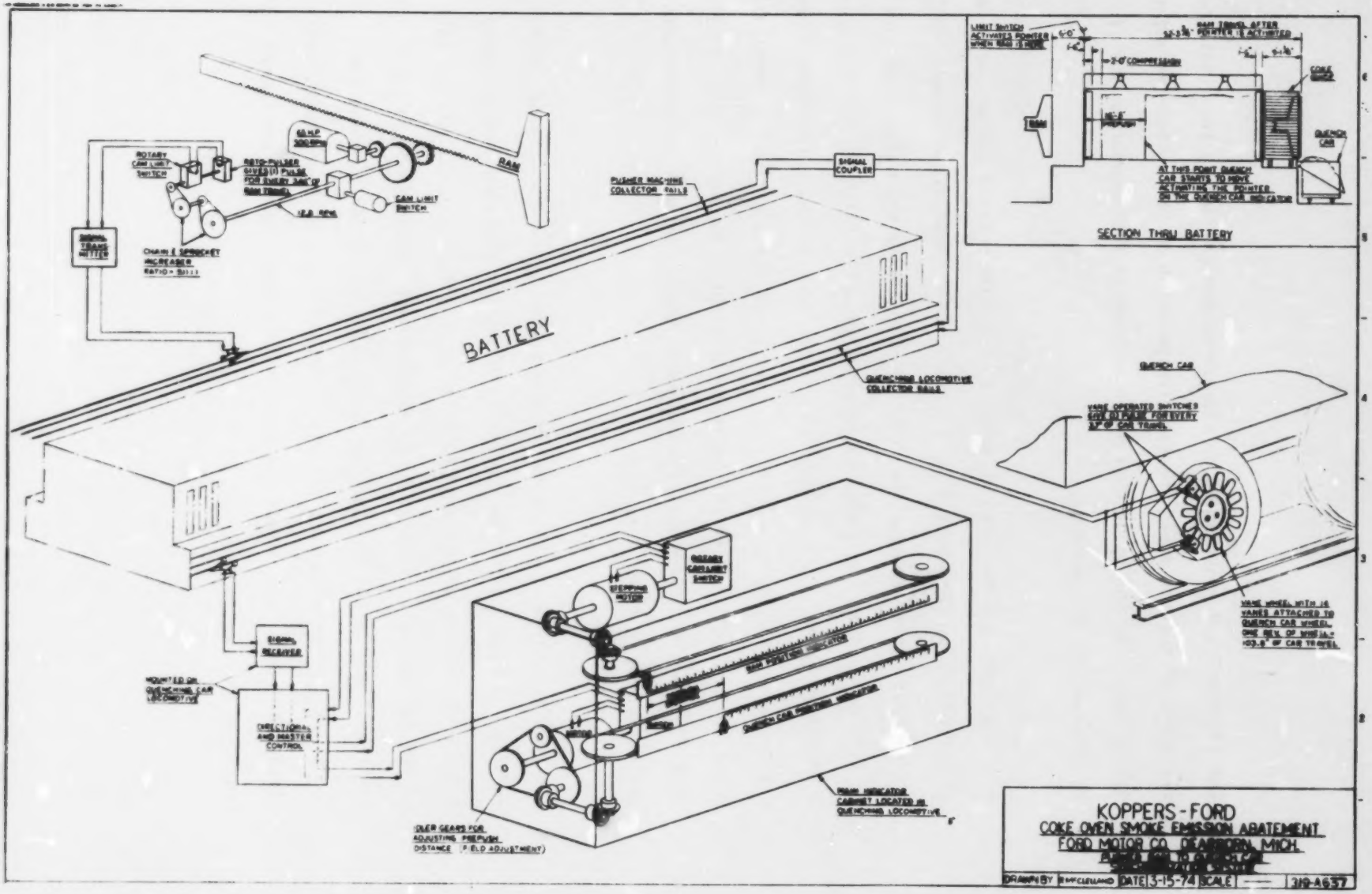
BATTERY
RAM
ROTARY CAM LIMIT SWITCH
CHAIN & SPROCKET INCREASER RATIO = 5:1
CAM LIMIT SWITCH
PUSHER MACHINE COLLECTOR RAILS
SIGNAL COUPLER
QUENCHING LOCOMOTIVE COLLECTOR RAILS
SECTION THRU BATTERY
AT THIS POINT QUENCH CAR STARTS TO MOVE ACTIVATING THE POINTER ON THE QUENCH CAR INDICATOR
QUENCH CAR
VANE WHEEL WITH 16 VANES ATTACHED TO QUENCH CAR WHEEL
SIGNAL RECEIVER
MOUNTED ON QUENCHING CAR LOCOMOTIVE
DIRECTIONAL AND MASTER CONTROL
ROTARY CAM LIMIT SWITCH
STEPPING MOTOR
MAIN INDICATOR CABINET LOCATED IN QUENCHING LOCOMOTIVE
IDLER GEARS FOR ADJUSTING PUSHER DISTANCE FIELD ADJUSTMENT
KOPPERS - FORD
COKE OVEN SMOKE EMISSION ABATEMENT
FORD MOTOR CO. DEARBORN, MICH.
DRAWN BY CLEVELAND DATE 3-15-74 SCALE — 319-A637

FIG. 9 PAGE 29

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The synchronization system is an electro-mechanical device that indicates via a set of pointer dials the relative position of the pusher ram and the quench car. The indicator cabinet is located in the locomotive cab to be observed by the operator.

A roto-pulsar unit has been attached to the pusher ram drive and emits an electrical pulse for every 3 in. of ram travel. This pulse is sent via a signal transmitter through the pusher machine collector rails which are in turn coupled to the quench locomotive collector rails by a signal coupler. A signal receiver on the quench locomotive receives the pulse signals from the pusher ram drive and by a series of relays energizes a stepping motor that moves the pointer dial in the indicator cabinet. The pointer dial starts to move from left to right when the ram head enters the oven and continues until the ram is fully extended.

The pointer dial that indicates the quench car travel is located in the indicator cabinet below the ram position pointer dial, (but not directly in line,) with the quench car pointer being approximately 7 in. to the right of the ram pointer. This 7 in. is equal to approximately 16 ft. 3 in. of ram travel and is called the "Pre-Push" distance or the distance the ram travels after it enters the oven, makes contact with the coke, compresses the coke, and pushes enough coke into the front of the quench car requiring the car to be moved.

The quench car pointer dial is also moved by a stepping motor that receives its pulses from a set of vane operated limit switches located on the rear outside wheel of the quench car. When the quench car begins to move, a vane wheel attached to the axle of the car passes through the limit switches momentarily closing a circuit that sends an electrical pulse to the stepping motor for every 3 in. of quench car travel.

A series of gears between the stepping motors and the pointer dials compensates for the difference in overall movement between the ram and the quench car and also allows for changes in the "Pre-Push" distance, if desired.

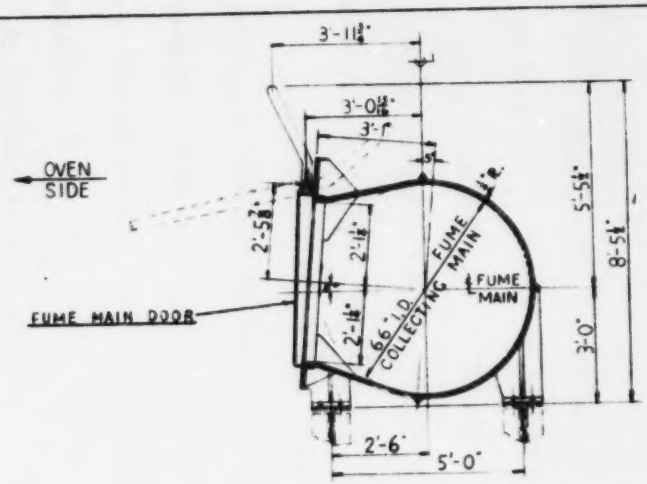
In operation the locomotive operator spots the quench car under the hood, turns the synchro system "on", then indicates he is ready to catch. He watches the ram position indicator, and when the ram head enters the oven, the pointer dial starts to move from left to right slowly. When the ram position indicator moves approximately 7 in., it will be directly in line with the quench car pointer, and he will move the car slowly keeping the pointers in line. When the ram is fully extended, the ram pointer will be at the extreme right of the indicator cabinet and the quench car will have moved so that its pointer will also be in line at the extreme right indicating that the push is complete. The operator then pushes the reset button, and while the pointer dials return to their original position the operator proceeds to the quench station.

D. Changes to the Locomotive include extending the cab to house the synchronization indicator cabinet and also adding the synchronization master control cabinet to the outside of the cab.

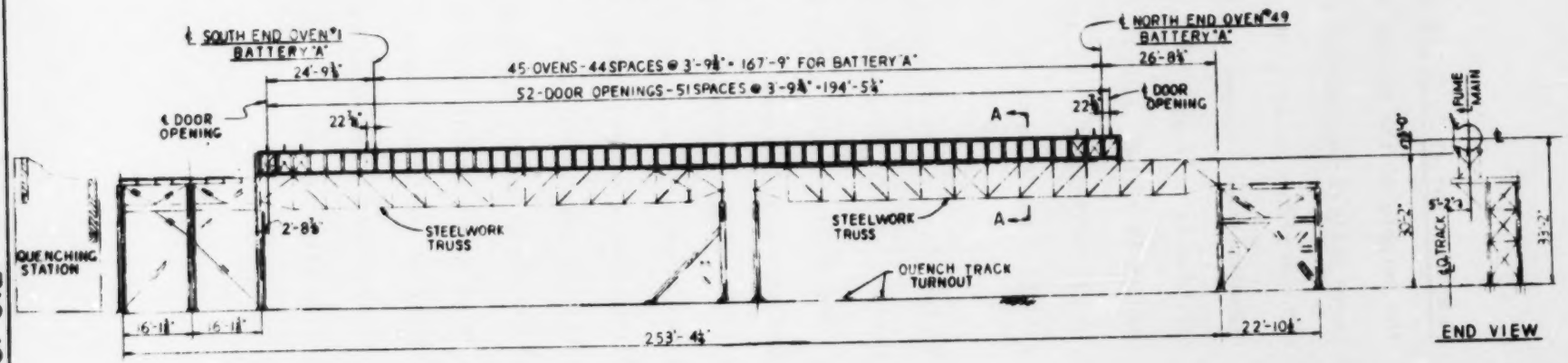
E. Fume Collecting Main (Figure 10 - Drawing 319-A635)

The fume collecting main runs the full length of the battery. It is a 66 in. I.D., with 1/2 in. wall, tubular steel section having one flat side facing the oven on which are mounted 52 doors. Each door is approximately 4 ft. 5 in. high by 2 ft. 8 in. wide and is hinged at the top having a lever that protrudes upward. Forty-six doors are required to service the 45 ovens, and there are 6 spare doors on the south end of the main for testing purposes. The flat surface of the fume main is slanted 5^{o} off vertical to allow the weight of the door to assist in sealing the adjustable knife edges that run the perimeter of each door.

The fume main has a walkway its full length with a service platform on either end; the main is supported approximately 33 ft. above the quench track by a steel box truss that spans approximately 106 ft. between towers. In addition to the fume main, the truss also supports the elevated third rail for the fume hood. There are sampling ports for test purposes along the entire length of the main.



ENLARGED SECTION-AA THRU MAIN



ELEVATION
(LOOKING WEST)

END VIEW

KOPPERS - FORD
COKE OVEN SMOKE EMISSION ABATEMENT
FORD MOTOR COMPANY
FUME COLLECT. MAIN-GENL. ARRG'T. & SECTIONS
DR. BY: R.T. SATTLER | DATE: 5-15-74 | SCALE: NONE | 319-A636

FIG. 10 PAGE 33

F. Fume Main Butterfly Valve (Figure 11 - Drawing 319-A630)

The purpose of the butterfly valve at the south end of the fume main is to relieve the suction in the main momentarily, thus requiring minimum effort to open the fume main doors. The valve is 30 in. in diameter and is opened and closed with an electric cylinder. The cylinder is activated by a Femco signal received from the coke guide when it is racked into the oven and prior to the fume main doors being opened. After the doors are opened a Femco signal is sent to the butterfly valve to close.

G. Venturi Scrubber (Figures 12 and 13 - Drawings 319-A633-634)

The gas scrubber system is located at the south end of the battery. As the collected, hot gases are conveyed down the fume main under suction pressure, they first meet with the venturi scrubber which is a high energy wet-type scrubber equipped with a variable throat slide block damper and designed to operate at a pressure differential of 60 in. w.c. Plant service water injected through water sprays located ahead of the throat of the venturi provides a sheet of water for complete coverage of the throat area. The high velocity gases when passing through the throat area will atomize the water which results in the dust particles being entrained in the water droplets. The venturi scrubber is made of COR-TEN steel, with stainless steel water deflection plates in the tapered throat area. The spray nozzles are equipped with manual reamers.

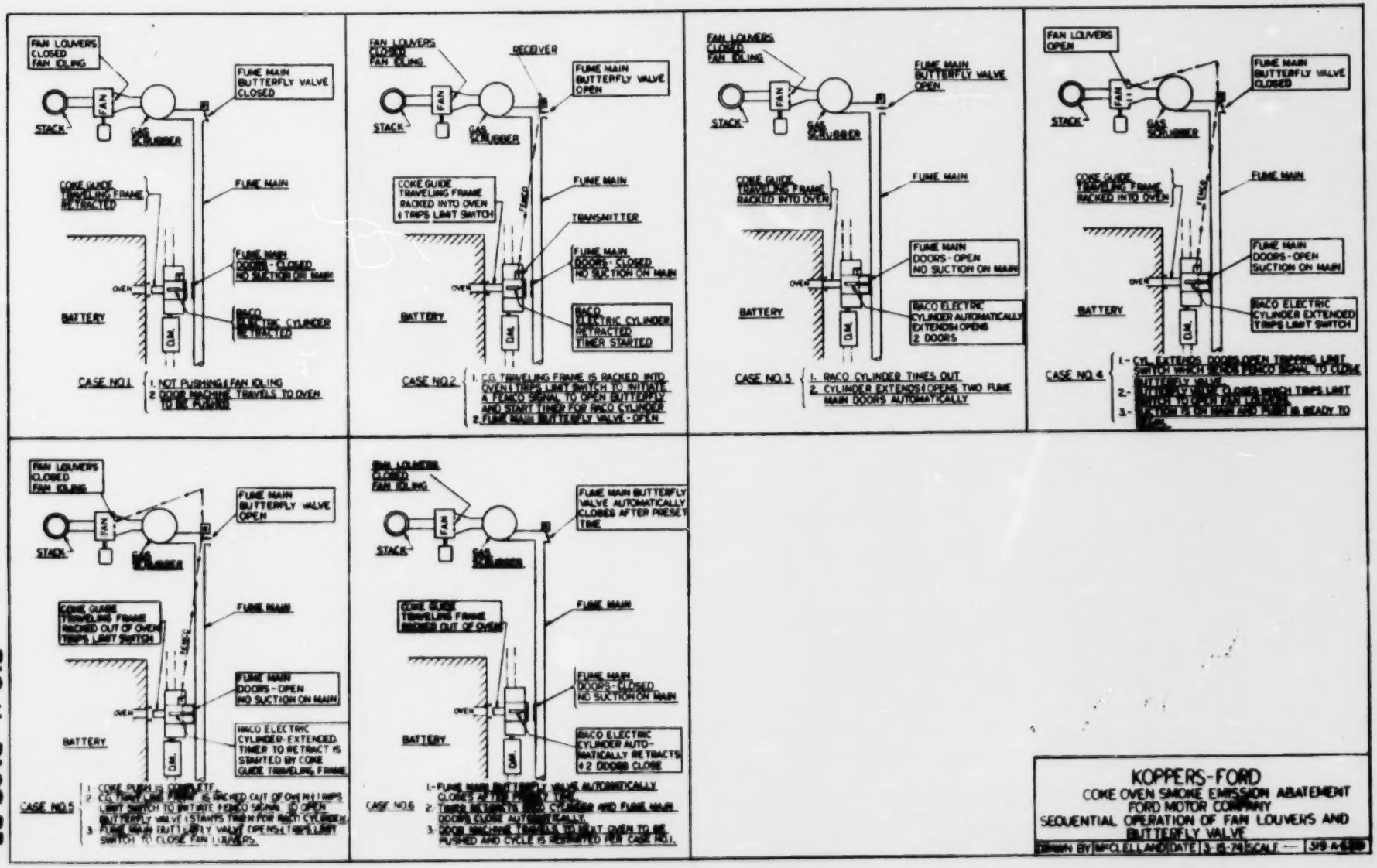

FAN LOUVERS CLOSED FAN IDLING
FLUME MAIN BUTTERFLY VALVE CLOSED
STACK
FAN
GAS SCRUBBER
COKE GUIDE TRAVELING FRAME RETRACTED
FLUME MAIN
FLUME MAIN DOORS - CLOSED NO SUCTION ON MAIN
OVEN
BATTERY
D.M.
RACO ELECTRIC CYLINDER RETRACTED
CASE NO.1
1. NOT PUSHING & FAN IDLING
2. DOOR MACHINE TRAVELS TO OVEN TO BE PUSHED
FAN LOUVERS CLOSED FAN IDLING
RECEIVER
FLUME MAIN BUTTERFLY VALVE OPEN
COKE GUIDE TRAVELING FRAME RACKED INTO OVEN & TRIPS LIMIT SWITCH
FEMCO
TRANSMITTER
FLUME MAIN DOORS - CLOSED NO SUCTION ON MAIN
RACO ELECTRIC CYLINDER RETRACTED TIMER STARTED
CASE NO.2
1. C.G. TRAVELING FRAME IS RACKED INTO OVEN & TRIPS LIMIT SWITCH TO INITIATE A FEMCO SIGNAL TO OPEN BUTTERFLY AND START TIMER FOR RACO CYLINDER
2. FLUME MAIN BUTTERFLY VALVE - OPEN
FAN LOUVERS CLOSED FAN IDLING
FLUME MAIN BUTTERFLY VALVE OPEN
COKE GUIDE TRAVELING FRAME RACKED INTO OVEN
FLUME MAIN DOORS - OPEN NO SUCTION ON MAIN
RACO ELECTRIC CYLINDER AUTOMATICALLY EXTENDS & OPENS 2 DOORS
CASE NO.3
1. RACO CYLINDER TIMES OUT
2. CYLINDER EXTENDS & OPENS TWO FLUME MAIN DOORS AUTOMATICALLY
FAN LOUVERS OPEN
FLUME MAIN BUTTERFLY VALVE CLOSED
COKE GUIDE TRAVELING FRAME RACKED INTO OVEN
FLUME MAIN DOORS - OPEN SUCTION ON MAIN
RACO ELECTRIC CYLINDER EXTENDED TRIPS LIMIT SWITCH
CASE NO.4
1 - CYL. EXTENDS, DOORS OPEN TRIPPING LIMIT SWITCH WHICH SENDS FEMCO SIGNAL TO CLOSE
2 -
3 -
FAN LOUVERS CLOSED FAN IDLING
FLUME MAIN BUTTERFLY VALVE OPEN
COKE GUIDE TRAVELING FRAME RACKED OUT OF OVEN TRIPS LIMIT SWITCH
FLUME MAIN DOORS - OPEN NO SUCTION ON MAIN
RACO ELECTRIC CYLINDER - EXTENDED TIMER TO RETRACT IS STARTED BY COKE GUIDE TRAVELING FRAME
CASE NO.5
1. COKE PUSH IS COMPLETE
2. C.G. TRAVELING FRAME IS RACKED OUT OF OVEN & TRIPS LIMIT SWITCH TO INITIATE FEMCO SIGNAL TO OPEN BUTTERFLY VALVE & STARTS TIMER FOR RACO CYLINDER
3. FLUME MAIN BUTTERFLY VALVE OPENS & TRIPS LIMIT SWITCH TO CLOSE FAN LOUVERS
FAN LOUVERS CLOSED FAN IDLING
FLUME MAIN BUTTERFLY VALVE AUTOMATICALLY CLOSES AFTER PRESET TIME
COKE GUIDE TRAVELING FRAME RACKED OUT OF OVEN
FLUME MAIN DOORS - CLOSED NO SUCTION ON MAIN
RACO ELECTRIC CYLINDER AUTOMATICALLY RETRACTS & 2 DOORS CLOSE
CASE NO.6
1 - FLUME MAIN BUTTERFLY VALVE AUTOMATICALLY CLOSES AFTER PRESET TIME
2 - TIMER RETRACTS RACO CYLINDER AND FLUME MAIN DOORS CLOSE AUTOMATICALLY
3 - DOOR MACHINE TRAVELS TO NEXT OVEN TO BE PUSHED AND CYCLE IS REPEATED PER CASE NO.1
KOPPERS-FORD
COKE OVEN SMOKE EMISSION ABATEMENT
FORD MOTOR COMPANY
SEQUENTIAL OPERATION OF FAN LOUVERS AND BUTTERFLY VALVE
DRAWN BY McCLELLAND
DATE 3-15-74
SCALE ---
J49-A-6

FIG. 11 PAGE 35

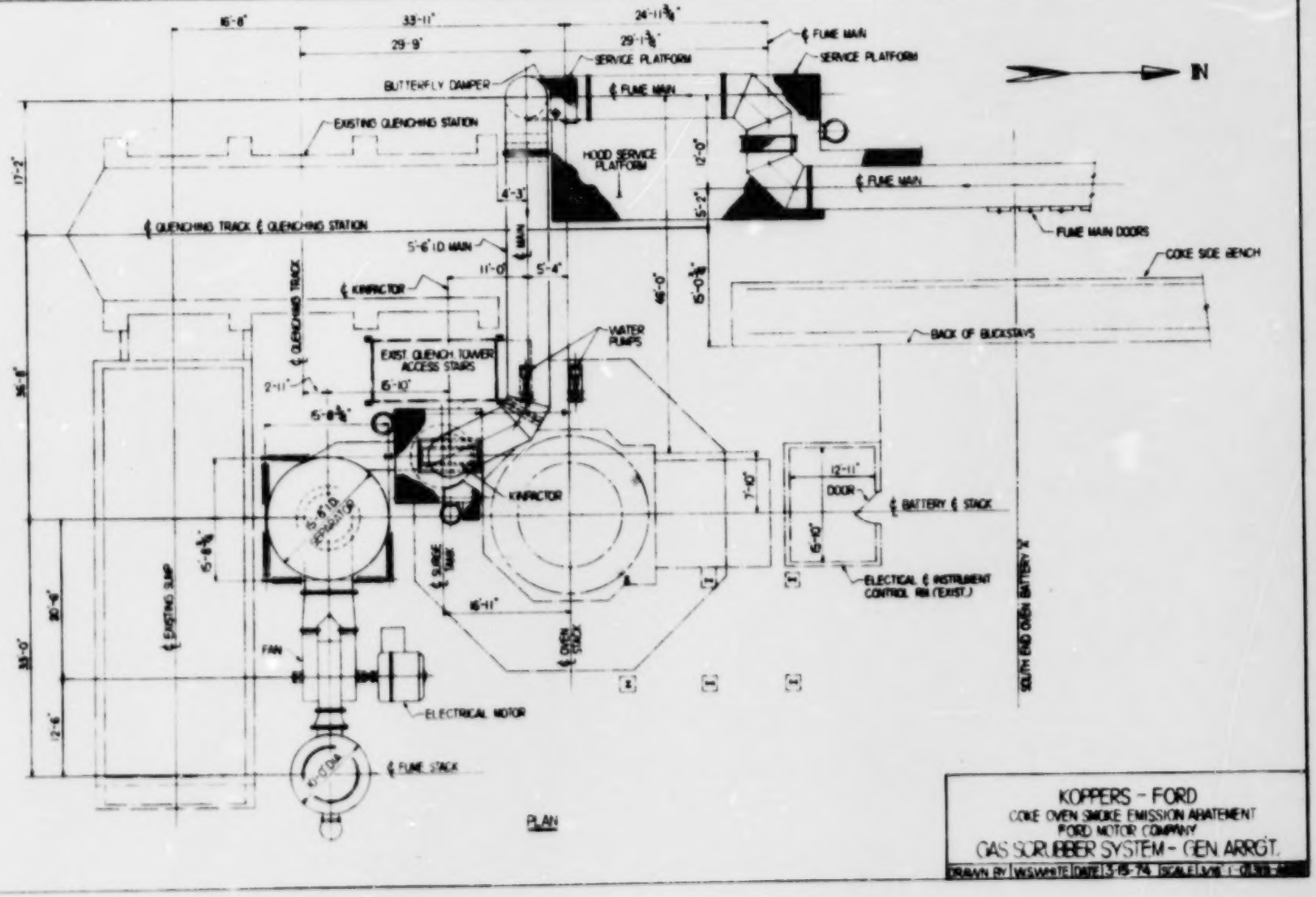


FIG. 12 PAGE 37

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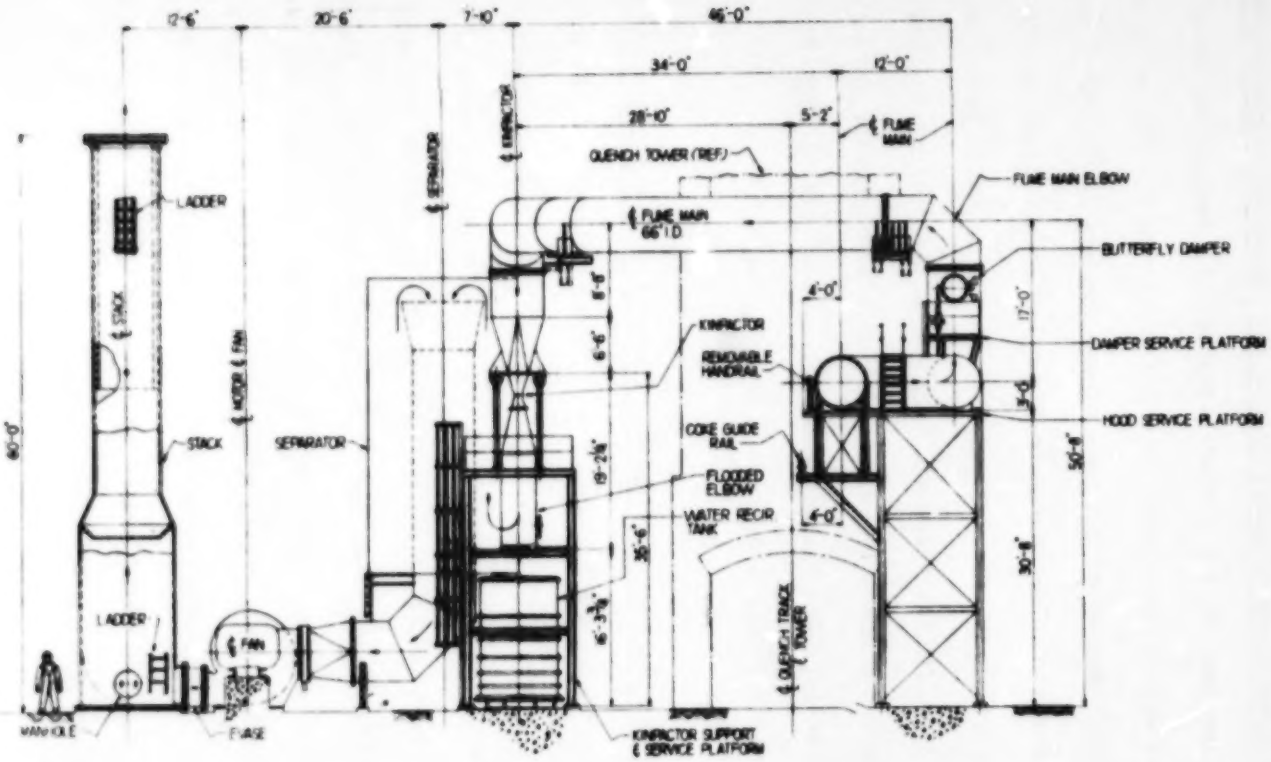

KOPPERS - FORD
COKE OVEN SMOKE EMISSION ABATEMENT
FORD MOTOR COMPANY
GAS SCRUBBER SYSTEM - ELEV ARRGT.
DRAWN BY W.G.WHITE DATE 3-15-78 SCALE 3/16" = 1'-0" 339-A-634

FIG. 13 PAGE 39

H. Flooded Elbow (Figures 12 and 13 - Drawings 319-A633-634)

After leaving the venturi scrubber the descending gases, spray water and wetted dust particles will enter the flooded elbow which will change the direction of the flow ninety degrees (90°) and direct it into the cyclone separator. The change in direction of the gases in the elbow will result in the heavier dust and entrained water particles dropping out of the gas steam and into the water pool on the bottom of the flooded elbow. The water pool will also protect the elbow from dust abrasion. The flooded elbow is made of 3/8 in. COR-TEN steel, with a clean-out door and a water drain connection.

J. Cyclone Separator (Figures 12 and 13 - Drawings 319-A633-634)

From the flooded elbow, the scrubbed gases enter tangentially into the lower level of the cyclone separator where centrifugal forces, due to the cyclonic action of the gas flow, cause the water droplets to separate out of the gas stream. The droplets collect on the outer wall of the separator and flow down to a drain at the bottom. The gases, free of entrained water, exit at the top of the separator and are directed downward through a 76 in. diameter duct to the exhaust fan at yard level. The 3/8 in. thick, COR-TEN steel separator is 15 ft. 8 in. in diameter by 31 ft. 0 in. high and is designed to operate at a pressure of minus 65 in. w.c. at the outlet connection.

K. Induced Draft Fan (Figures 12 and 13 - Drawings 319-A633-634)

The fan is designed for the following normal operating conditions:

Gas flow	112,000 acfm
Gas temperature	132°F
Gas density at fan inlet	0.0525 lb./cu. ft.
Static pressure	Minus 60 in. w.c.
WR^2 (rotor)	12,800 lb. - ft.^{2}

The fan is a direct driven type, arrangement 3, with motor operated variable inlet dampers that place the fan on idle between pushes. The operation of these inlet dampers is explained in Figure 11 (Drawing 319-A630). The fan has a 3/8 in. COR-TEN steel housing and 1/4 in. thick blade liners. The bearings are ring oiled, self-aligning and water cooled. The fan is supported on a fabricated steel sub-base with pedestals and pedestal caps under each bearing. The fan blades are water sprayed to insure against particle build-up by two (2) nozzles located in the fan housing. Each nozzle delivers 3 gpm of city water and there are three (3) drains in the fan housing that carry the water to the drain sump.

The fan is driven by a 2000 h.p., 1785 rpm, 4160 v.a.c., 240 amp, weather protected, NEMA Class II induction motor direct connected through a 4-1/2 in. Fast's flexible coupling. The motor is mounted on a sole plate and the bearings are oil cooled.

NOTE: The induced draft fan, the 2000 h.p. motor and the starting switchgear, transformers and resistance rack that supply the required 4160 v.a.c. were supplied by Ford Motor Company.

M. Exhaust Stack (Figures 12 and 13 - Drawings 319-A633-634)

From the induced draft fan the gases are directed through an evase section into the exhaust stack that, in turn, directs the gases vertically above yard level before emitting them to the atmosphere.

The 60 ft. high stack is 10 ft. in diameter at the base with a 7 ft. 6 in. diameter top section and is made of 3/8 in. thick COR-TEN steel. A ladder extends the full height, and a manhole inspection cover is located approximately 3 ft. above yard level.

To attenuate the noise emanating from the stack an Aeroacoustic model SSA-5 silencer of the stack-stuffer type is used.

N. Water Recirculating Tank (Figures 12 and 13 - Drawings 319-A633-634)

Dirty water from the flooded elbow and cyclone separator drains by gravity into a 5,000 gal. water recirculating tank located beneath the flooded elbow at yard level.

The 8-1/2 ft. diameter by 13 ft. high tank has two compartments that are separated by a weir. The dirty water enters one side of the tank, and during the residence time before it flows over the weir, the solid

particles settle to the bottom where they are drained off to the quenching sump at approximately 50 gpm. Make-up water to the tank is mill service water regulated by a level control valve.

P. Water Recirculating Pumps (Figures 12 and 13 - Drawings 319-A633-634)

From the clean side of the water recirculating tank, water is pumped to the venturi scrubber spray nozzles by two (2) water recirculating pumps, one operating and one standby. Each pump is of the horizontal centrifugal type designed to deliver 1,000 gpm at 100 ft. tdh. Pressure switches provide for automatic start-up of the non-operating pump on loss of water pressure in the system. Each pump is driven by a 50 h.p. motor.

Q. Electrical and Instrument Control Panels (Figure 5 - Drawing 319-A629)

Cabinets to house the electrical equipment and instruments to control the fan, fan motor, annunciators, and related components were placed in the existing control room at the south end of "A" battery and in the reversing room between "AX" and "B" batteries.

SECTION V

ENVIRONMENTAL POSTURE

The design concepts introduced with this new system were developed for the express purpose of eliminating the air pollution created from the pushing of incandescent coke from the ovens into a shallow-bed car for transport to a batch type station for quenching.

Potentially, substantial emissions of smoke and particulate are discharged into the atmosphere during the period when the coke passes through the guide, when the coke breaks up leaving the guide, and during the distribution of coke into the quench car. The quantity of the emissions encountered during this operation is affected by the completeness or efficiency of the coking process within that particular oven. If the push contains coke that is not completely carbonized, the combustion of the volatile matter will cause considerably more emissions than a push that contains only coke that has been properly carbonized.

The method of pushing and the type of machinery (i.e. coke guide, door machine, locomotive, and quench car) used at Ford Motor Company are of the conventional design used in all but a few coke plants throughout the world.

By placing a hood over the coke guide and quench car the objectives of the system are to capture all of the gases and particulate matter, which are generated from the coke push, as well as the up-drafted air. With the

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incandescent coke, the combustible gases, and the indrafted air, the gases are burned to CO_2 and H_2O. In addition, the particulate matter is scrubbed out of the gas stream, ultimately discharging only cooled gas, consisting mostly of air, to the atmosphere.

For particulate matter to be collected and removed from a hood that covers the emission source, sufficient capture velocities must be maintained to keep the matter airborne until it reaches the cleaning device. The hood at Ford is designed with a clearance of 2 in. between the hood and quench car when the seal plates are down and the car is in position. This clearance would give an indraft velocity of 30 ft./sec. and be more than ample to negate the effects of external air movements, such as wind. Due to the settling and movement of the quench tracks, the actual clearance after construction was found to be considerably greater than 2 in. in some locations, and the indraft velocities were measured at 12 ft./sec. which was still sufficient to capture the emissions in all but the highest of wind conditions. This greater clearance allows more air to be drawn into the gas stream and results in lower gas temperatures and greater gas density. The average gas temperature in the fume main just downstream of the oven being pushed was found to be approximately 400°F instead of the design temperature of 650°F as indicated on Figure 3 (Drawing 319-A627). This decreased temperature was due mainly to the larger clearances and the fact that the operator did not always

lower the seal plates before each push. Air leakage into the system from sources such as the perimeter of doors, expansion joints in the fume main, and the butterfly valve seat was found to be 5% as determined by Orsat analysis taken at both ends of the fume main.

An analysis of the gas before scrubbing indicated that it contained 1.76 lbs. of particulate matter per ton of coke pushed. The Ford ovens contain 12 tons of coke which means that over 21 lbs. of matter are generated from each push. The Wayne County, Michigan, air emission code requires that the outlet loading from the stack must be less than 0.05 grains/scf which would require a scrubber efficiency of 97.5%.

From tests made by Koppers the outlet stack loading was found to be 0.02 grains/scf indicating that the gas cleaning system, when used as designed, has an efficiency of 99%.

The water requirements of the system are mostly for the sprays in the venturi scrubber which require approximately 890 gpm of recirculated water. The solids are removed from the water by a settling chamber in the recirculating water tank. The chamber has a continuous blowdown of 50 gpm to the quenching sump where the solids are clam-shelled out in the normal manner along with the coke breeze from the quenching tower. Make-up water to the system is mill cooling water. Chemical analysis of the blow-down water compared to the make-up water showed only slight increases in cyanide, phenols, and thiocyanates, with no increase of ammonia. The remainder

of the water required is city water for the cooling of fan bearings and fan blade sprays, with the drains from each also going to the quenching sump.

To attenuate the noise created at the gas scrubber area, the fan housing was sprayed with a 3/8 in. thick coat of sound deadening material and the stack was equipped with a silencer of the stack-stuffer type.

When the system was first started in June 1972, the noise at the stack base was excessive and the cause was found to be that the evase section at the fan exit formed a ninety degree (90^{o}) angle with the stack, and the air blast against the outer wall of the stack created excessive vibration. By placing brick in the stack base forming a radius to turn the air blast ninety degrees (90^{o}), the noise and vibration were reduced considerably. Noise level at the stack base after the brick was installed was 101 DbA dropping off to 81 DbA at a distance of 60 ft. from the stack at yard level.

SECTION VI

CAPITAL COST ESTIMATES

The following cost estimates represent the installed cost of facilities including overhead, engineering, material, and labor. They are considered representative of project cost prevailing to June 1972.

1. Coke Guide Fume Hood including:
   (a) Modifications to existing coke guide, door machine, quench car, and locomotive.
   (b) Pusher machine to quench car synchronization unit. ---- $ 460,000

2. Fume Collecting Main including:
   (a) Main and truss
   (b) Support towers, foundations, and piling
   (c) Elevated third rail ---------- $ 523,000

3. Gas Scrubber including:
   (a) Venturi scrubber
   (b) Cyclone separator with flooded elbow
   (c) Fan and fan motor
   (d) Stack
   (e) Recirculating water tank and pumps

(f) Foundations and structural steel	
(g) Instruments and controls	
(h) Piping and electrical ----------	$ 817,000
Total	$1,800,000

The distribution of the total cost is estimated as follows:

Engineering, overhead and administrative expense ----------	$ 620,000
Material ----------	600,000
Labor ----------	580,000
Total	$1,800,000

The above price reflects the cost of the "Coke Oven Smokeless Pushing System" as installed at Ford Motor Co. Some items that could affect the cost of future installations are:

1. The oven height, determining the size of the hood.
2. The number of ovens, determining the length of the fume main.
3. The number of support towers for the fume main and the distance between each tower.
4. The location of the Gas Cleaning System relative to the quenching sump.
5. Obstructions on the coke side of the battery requiring special design of the fume main, truss, and support towers.

6. The materials that the Gas Cleaning System components and Coke Guide Fume Hood are made from.
7. The number and size of the pilings required due to soil analysis.

SECTION VII

OPERATING COSTS, UTILITY REQUIREMENTS, AND MAINTENANCE

An evaluation of utility costs to operate the Smokeless Pushing System is shown on Table 1.

The control panel for the system operation is located on the door machine and all functions are initiated at that point by the door machine operator requiring no additional personnel over the conventional method of pushing.

For the most part the major expense in the operation of the system is the electrical utility requirements for the fan motor and water recirculating pump motor.

During an average 1 hour operation, there are approximately four pushes. When the guide is racked into the oven in the normal manner (approximately 1 to 2 minutes before the push), the system is automatically placed on full suction. The push lasts for 40 seconds which means that the fan is on full power for approximately 2-1/2 minutes at each push or 10 minutes of each hour. For the remaining 50 minutes the fan is at idle consuming half of its rated power or 1000 h.p.

The water recirculating pump runs constantly at 50 h.p.

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TABLE I

UTILITY REQUIREMENTS

ELECTRICAL

QUANTITY	DESCRIPTION		KW
1	Fan Motor ----------		850
	1/6 Time at 2000 h.p. (full load)		
	5/6 Time at 1000 h.p. (idle)		
2	VENTURI SCRUBBER WATER PUMPS ----------		41
	1 operating and 1 spare		
	50 h.p.		
4	ELECTRIC CYLINDERS	Intermittent Operation	
1	FAN DAMPER CONTROL MOTOR ----------		0.38
		TOTAL KW/HOUR ---------	891.38

KWH per year = 24 hrs. x 365 days x 891.38 = 7,808,488

WATER

50 gpm mill water make-up to recirculating water tank

50 gpm x 60 min. x 24 hr. x 365 days = 26,280,000 gal./yr.

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The four electric cylinders that operate the fume hood shroud, seal plates, and butterfly valve along with the motor that controls the fan louvers are intermittent in operation and the power consumption is negligible as shown on Table I.

The 50 gpm mill water make-up to the water recirculating system at Ford is drawn from the Rouge River Canal at a cost of pumping, only.

Maintenance requirements are listed on Table II with required preventive maintenance being the only type that can be projected. Maintenance due to incorrect operation, malfunction, or accidental damage are considered to be no more than any piece of operating machinery of similar magnitude.

TABLE II

REQUIRED MAINTENANCE

1. Check lubrication to fan and motor bearings	weekly
2. Ream venturi sprays	twice/week
3. Open blow-down valve on dirty side of recirculating water tank to max. position for 10 minutes then return to 50 GPM setting.	once/shift
4. Check oil level of water pumps.	weekly
5. Switch operating water pumps.	weekly
6. Check fan inlet louvers for travel.	daily
7. Check to see that fume hood shroud extends fully and seals against fume main	daily
8. Check all indicating lights to be sure limit switches are operating and bulbs are not burned out.	daily
9. Observe the following instruments to be sure system is operating properly	daily

a) Venturi scrubber differential pressure gauge

b) Fan bearing temperature gauges

c) Motor bearing temperature gauges

d) Fan ampere recorder

e) Gas temperature recorder

f) Water flow recorder

g) Water pressure gauge

h) Annunciators for fault alarms

The above maintenance should require an average of 1 hour and 30 minutes per day.

SECTION VIII

POST START-UP MODIFICATIONS

The "Coke Oven Smokeless Pushing System" was placed into operation in June 1972. It was soon noticed that the noise and vibration emanating from the base of the stack was excessive. This was corrected by adding brick in the stack base to form a turning radius for the air blast from the fan outlet.

The synchronization system initially utilized a set of gears and a roto-pulsar unit mounted on the quench car wheel. The critical alignment and the presence of water and coke breeze accounted for the rapid deterioration of these components, and a set of vane operated limit switches was then introduced to eliminate any physical contact in this environment. Other minor problems have plagued the synchronization system since start-up, resulting in Ford's removing the baffle plates from the quench car, as well as cutting back the end plates so the quench car operator can visually make the catch. When the synchronization system is reliably operating again, the baffles and end plates are to be replaced to restore the system to its designed capabilities.

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After several months operation, it was noticed that the operator did not always lower the seal plates prior to each push, which results in even larger areas where ambient air can infiltrate the hood. After one year the plates were never lowered, so it was decided to remove the electric cylinders and fix the seal plates in a position with sufficient clearance to allow the quench car and locomotive to pass by.

In spite of the seal plates remaining in the up position, the baffle plates being removed from the quench car, and the end plates of the quench car being cut back, the hood continues to do a satisfactory job of collecting the pushing emissions in all but extreme conditions, such as severely "green" ovens and high winds.

Due to the uncertainty of the suction created in the main or the effectiveness of the seal that runs the perimeter of each door, the fume main butterfly valve was added to relieve the suction and assure that the electric cylinder could open the doors. In late 1973, a test was made keeping the butterfly valve closed, then placing the main on full suction and opening the doors. Several days of operation in this manner proved that the butterfly valve was not required, so it was welded shut.

During the first winter, heat tracing was added to the water system to prevent freezing and an enclosure with a space heater was built over the

recirculating pumps by Ford.

The above mentioned modifications, through the combined efforts of Ford and Koppers, bring the operating system up to date as of this writing, with numerous design criteria being established for future applications.

SECTION IX

UNITS OF MEASURE - CONVERSIONS

Environmental Protection Agency policy is to express all measurements in Agency documents in metric units. When implementing this practice will result in undue cost or lack of clarity, conversion factors are provided for the non-metric units used in a report. Generally, this report uses British units of measure. For conversion to the metric system, use the following conversions:

To convert from	To	Multiply by
cfm	m^3/sec	0.0004719
^oF	^oC	5/9 (^oF-32)
ft.	m	0.3048
gal.	l	3.785
gpm	l/sec	0.0631
gr/scf	mg/Nm^3	2288.136
hp	W	745.7
in.	m	0.0254
in. wc	N/m^2	248.84
lb	kg	0.454
tons (short)/hr	kg/hr	907.185

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